

Review

Energy Poverty and Protection of Vulnerable Consumers. Overview of the EU Funding Programs FP7 and H2020 and Future Trends in Horizon Europe

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Abstract: Energy poverty—involving a combination of factors, such as low household incomes, high energy prices, and low levels of residential energy efficiency—is identified as a complex and increasing issue affecting people’s physical health, well-being, and social inclusion. Even though a shared identification of energy poverty is not yet agreed, this phenomenon has been recognized as an EU priority. Several EU legislative documents address the topic, trying to outline its boundaries and provide a framework for mitigative actions. At the same time, different research and demonstration projects have been funded to experiment and evaluate innovative approaches, strategies, and solutions and to promote good practices at national, regional, and local levels. This review paper presents some results of the “ZOOM” project (“Energy zoning for urban systems. Models and relations for the built environment”, funded by University of Bologna in the framework of Alma Idea 2017–ongoing), proposing a critical overview of the EU projects directly or indirectly connected to energy poverty—funded under the 7th Framework Program (FP7) and under Horizon 2020 Program (H2020). The aim of such a review is to highlight the main objectives, trends, and related topics of ongoing and concluded projects addressing energy poverty, in order to identify gaps and open issues and to understand the possible orientation and placement of this subject in the future EU research and innovation framework project, Horizon Europe.

Keywords: energy poverty; fuel poverty; vulnerable consumers; vulnerable households; energy vulnerability; energy efficiency; customer engagement; energy citizenship

1. Introduction

In recent years, Energy poverty has been recognized as an extensive and increasing issue that is impacting on people’s living standards and rights. Consequently, it has attracted growing policy and academic interest in Europe. The European Union embedded such phenomenon in the framework of the “Third Energy Package” [1–3], while the European Economic and Social Committee (EESC) warned about the consequences of the liberalization of energy markets and of the increasing energy vulnerability [4]. Nevertheless, common pan-EU indicators of energy poverty are not yet agreed upon, and various definitions of energy poverty are adopted both in literature and across EU countries [5,6]. Current EU legislation does not require Member States to adopt a common identification of energy poverty, but it does require them to define the concept of ‘vulnerable customers’—who may include individuals at risk of or in energy poverty—in order to comply with the requirements stemming from the Third Energy Package.

According to a widely accepted but general description [5,7], energy poverty is a condition when “individuals or households are not able to adequately heat, cool, or provide other required

energy services in their homes at affordable cost”, where energy services are commonly understood as the benefits of using energy in the home [8]. The EU Energy Poverty Observatory (EPOV) defines energy poverty as the “inability of a household to access socially and materially necessitated levels of energy services in the home” [9]. In this context, “socially necessary” generally means a standard of energy service that allows full participation in society, while the material dimension refers to the health consequences—because inadequately heated or cooled homes have harmful implications for the respiratory, circulatory, and cardiovascular systems, as well as for mental health and well-being [10].

The European Fuel Poverty and Energy Efficiency (EPEE) project, involving five EU Countries (Belgium, France, Italy, Spain, and the United Kingdom), laid the basis for an EU-wide shared definition of energy poverty by proposing to link it to “household’s difficulty, sometimes even inability, to adequately heat its dwelling at a fair, income indexed price” [11]. Subsequently, the European Commission defined “energy-poor households” as those with an effective share of energy products expenditure above a predefined threshold, set at “double the national average ratio number” [12]. The United Kingdom is the only country to have defined the threshold: “a household is in a situation of fuel poverty when it has to spend more than 10% of its income on all domestic fuel use, including appliances, to heat the home to a level sufficient for health and comfort” [13]. Given the differences in climate, heating methods, and income assessment, this percentage is not readily applicable to other countries. Therefore, the EPEE consortium proposed that each country adapt this general definition to reflect national characteristics and criteria, while retaining a common view of the problem [11].

This vision is also included in the EU Clean Energy for all Europeans package (CEP), a comprehensive update of the EU energy policy framework to assist the transition towards cleaner energy and to meet the commitments under the Paris Agreement [14]. The CEP rules require that “each EU Country should assess the number of households in energy poverty taking into account the necessary domestic energy services needed to guarantee basic standards of living in the relevant national context” [15] and specific national objectives on energy poverty are to be introduced in the National Energy and Climate Plans (NECPs).

The terms “energy poverty”, “fuel poverty”, “energy deprivation”, “energy vulnerability”, “energy precariousness”, and “consumer vulnerability” are often used interchangeably in relevant literature and by the EU institutions. The expression ‘fuel poverty’ has traditionally been used to refer to people in developed countries suffering from inadequate heating in the home; however, in these countries, the importance of other services (cooling, lighting, appliances, IT) has increased substantially in recent years so that heating consumption is no longer a sufficient indicator [16].

According to the latest survey data by the EU Energy Poverty Observatory (EPOV), almost 50 million people in the European Union are affected by energy poverty (source: EU Statistics on Income and Living Conditions, 2016), 44.5 million people were unable to keep their home warm in 2016, and 41.5 million people fell into arrears with their utility bills in 2016 [8]. The condition itself is based on a combination of low household incomes, high energy prices, and low levels of residential energy efficiency. As such, energy poverty does not fully overlap with income poverty, although many low-income households are also energy poor. Often, households suffering from fuel poverty combine low income with an additional degree of vulnerability, such as the elderly, the disabled, and single-parent families.

As pointed out by the European Union Statistics on Income and Living Conditions (EU-SILC) [17], the highest percentage of energy poor households are concentrated in postsocialist Central and Eastern Europe (ECE) countries and in the Mediterranean Sea region, with respectively 20.0% and 16.6% of inadequately heated homes during the winter period against the European average of 12.8% [18].

The number of “vulnerable” households is expected to increase due to rising energy prices [11], climate change, and the transition to green energy. The increase in the average temperature increases the demand for cooling. This trend has already manifested in Mediterranean countries: in Italy, since 2010, the peak demand for electricity in summer is higher than the peak in winter, while in the period 2014–2017, the demand for gas in winter was lower than the average of the previous 15 years [19].

Summertime energy poverty and space cooling difficulties are relatively under-explored: a holistic approach is thus needed. More specifically, it is necessary to combine the assessment of energy poverty considering the whole year and by including all energy services in the home [11].

The energy transition exerts upward pressure on energy prices: the EU electricity prices are affected by the systemic burden of supporting renewable energy and the mechanism for pricing CO₂ emissions; therefore, many researchers predict that EU electricity prices, among the highest in the world, will rise further in the coming decades due to energy transition [20] (European Commission, 2016 [21]). Moreover, the European Economic and Social Committee (EESC) warned of the implications of the liberalization of energy markets and of the current crisis on energy vulnerability [4].

From the late 2000s, several EU legislative documents address the issue of energy poverty, trying to outline its boundaries, provide an overall framework, and lay the ground for actions to mitigate the effects of such phenomenon. Articles 3 of Directive 2009/72/EC (European Parliament and the Council of the European Union, 2009a) and Directive 2009/73/EC (European Parliament and the Council of the European Union, 2009b) require Member States to ensure adequate safeguards to protect vulnerable customers and ask for a definition of the concept of vulnerable customers and appropriate measures to tackle energy vulnerability and energy poverty. EU Directive 2018/2002 (European Parliament and the Council of the European Union, 2018a) requires Member States to account for the need to alleviate energy poverty when designing policy measures to meet their energy saving obligations. Finally, the EU Directive 2019/944 (European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending (Directive 2012/27/EU)), referring to EU Regulation 2018/1999 of the European Parliament and of the Council of 11 December 2018, asks Member States to monitor the situation of energy poverty in their countries “taking into account the necessary domestic energy services needed to guarantee basic standards of living in the relevant national context, existing social policy and other relevant policies, as well as Commission indicative guidance on relevant indicators, including geographical dispersion, that are based on a common approach for energy poverty” [22].

The EU has also supported several research and demonstration projects to experiment and evaluate innovative approaches, strategies, and solutions aimed at alleviating energy poverty and promoting good practices at national, regional, and local levels. Nevertheless, the increasing interest in the topic was not matched with a deep investigation of the actual impacts and efficiency of the adopted measures [23]: most of the literature on energy poverty and affordability has focused on their conceptual definition, in particular on the identification of appropriate statistical measures [24].

The review paper presents some results of the ZOOM project (“Energy zoning for urban systems. Models and relations for the built environment”), funded by University of Bologna in the framework of Alma Idea; its objective is to give a critical overview of the EU FP7 and Horizon 2020 funded projects, addressing, directly or indirectly, energy poverty issues, in order to highlight the main goals, trends, related topics, gaps, and open issues. Moreover, the paper aims to understand the possible orientation and placement of the energy poverty subject in the future EU research and innovation framework project, Horizon Europe.

The paper is structured as follows: the “Objective and Methodology” Section 2 outlines the main aims, clarifying that the analysis and selection of energy poverty related projects do not aspire to cover the entirety of scientific production, but are focused on FP7 and H2020 ones. In addition, the section outlines the methodology used to select the projects. In Section 3, dedicated to “Project Results”, the systematization and comparison research is illustrated. Section 4, “Open Issues and Future Trends”, highlights the relation between FP7 and H2020 and the Horizon Europe framework. In Section 5, conclusions are presented.

2. Objectives and Methodology

The EU funding research and innovation programs are highly committed to addressing energy issues and related topics. This contribution presents a selection of those that are strictly related

to energy poverty and the major amount that addresses it collaterally, within more general energy frameworks. The analysis also aims at providing an overview of the possible future placement of the energy poverty subject within the targets and the key strategic orientations of Horizon Europe—the European Union Framework Program for Research and Innovation 2021–2027.

As a matter of fact, projects carried out under the framework programs for research and innovation, including the Intelligent Energy Europe program (IEE) and European Structural and Investment Funds programs [25], have produced knowledge and best practices at various scales that may serve as blueprints for similar initiatives to be implemented in the future, enabling further discussion and uptake in the next research and innovation programs [26].

In this paper, the expression ‘energy poverty’ has been assumed as preferable: according to Thomson [27], ‘energy poverty’ is to be preferred to ‘fuel poverty’, as the first is used in the vast majority of the EU policy documents since 2001.

General reports about the state of play of EU-funded innovation projects on energy poverty in Europe already exist (Joint Research Centre, 2019) [23]; for this reason the present research will focus exclusively on the Horizon 2020 program (H2020, 2014–2020) and the previous Seventh Framework Program (FP7, 2007–2013), because of the specific focus of those projects and, consequently, their high comparability.

During the same period of time, other EU initiatives have been carried out. Those that are mostly focused on energy poverty are:

- Engager—European energy poverty: agenda cocreation and knowledge innovation (2017–2022)—funded by the European Cooperation in Science and Technology organization (COST);
- EPOV—the EU Energy Poverty Observatory (2016–2019)—initiative by the European Commission;
- Evaluate—energy vulnerability and urban transitions in Europe (2013–2018)—funded by the European Research Council;
- EPEE—European fuel poverty and energy efficiency (2006–2009)—IEE funded project.

The list of the projects selected and reported in this paper has been filled in mainly by a keyword search on CORDIS, the Community Research and Development Information Service. CORDIS is the European Commission’s primary source for results from the projects funded by the EU’s framework programs for research and innovation (FP1 to Horizon 2020). The keywords used in the search were the following (last access 23rd January 2020):

- Energy poverty;
- Fuel poverty;
- Energy vulnerability;
- Vulnerable consumers;
- Vulnerable households.

The keyword search provides hundreds of project results: a multiplicity of project outputs is included as well, such as reports, events, deliverables, and final research summaries. The H2020 and FP7 projects were selected according to their pertinence and the availability of information, resources, documents, and materials, in order to be able to proceed with the knowledge phase and the deepening of their contents.

3. Projects Results—Systematization and Comparison

3.1. Selected FP7 and H2020 Projects Dealing with Energy Poverty Issues

The 43 projects identified throughout ZOOM research address energy-poor issues and implement measures to address causes and solutions (see Appendix A, where all projects are listed and organized in chronological order). At the time of writing, 16 of them are in progress. It must be highlighted that 7 projects, of the total of 16 ongoing projects, are centered on energy poverty, compared to only 5 of

the total of 27 completed projects (Figure 1a). This comparison allows us to state that the interest in, and the commitment to, energy poverty from the part of the EU Research and Innovation programs has been considerably increasing since 2017.

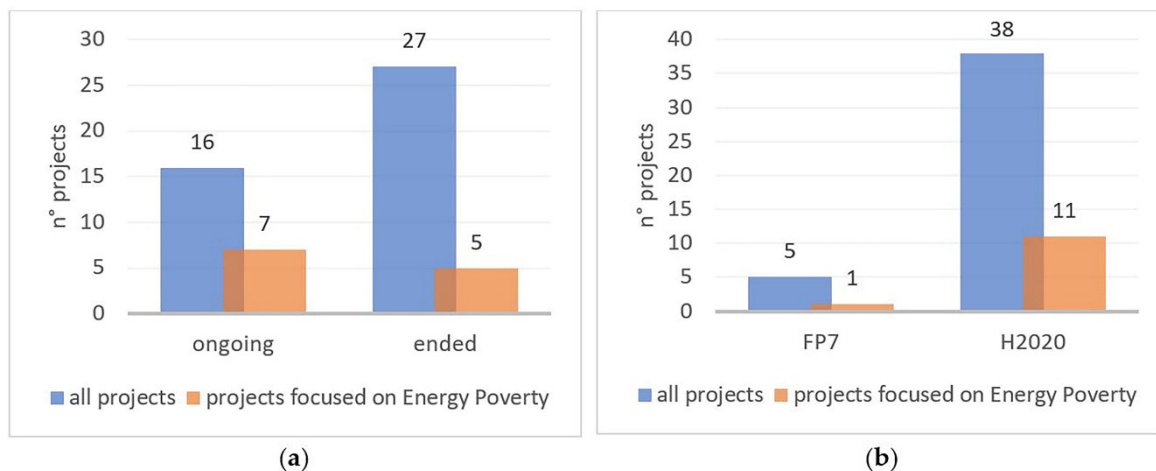


Figure 1. (a) Number of projects ongoing and ended; (b) number of projects per EU Research and Innovation program. Image elaborated by the authors.

This trend is even more evident observing Figure 1b, where the number of projects under FP7 and H2020 are represented: only 1 project has been developed under FP7 out of 11 developed under H2020. Of these, four started in 2019.

As shown in Figure 2, the trend of the number of funded projects over the years is not continuous, but after 2015 it has grown significantly. Especially in 2015, 2016, and 2017, most of the projects were not focused on energy poverty, rather the phenomenon was addressed as a secondary issue or among multiple objectives. In 2019, there is more accentuated attention given to the specific topic.

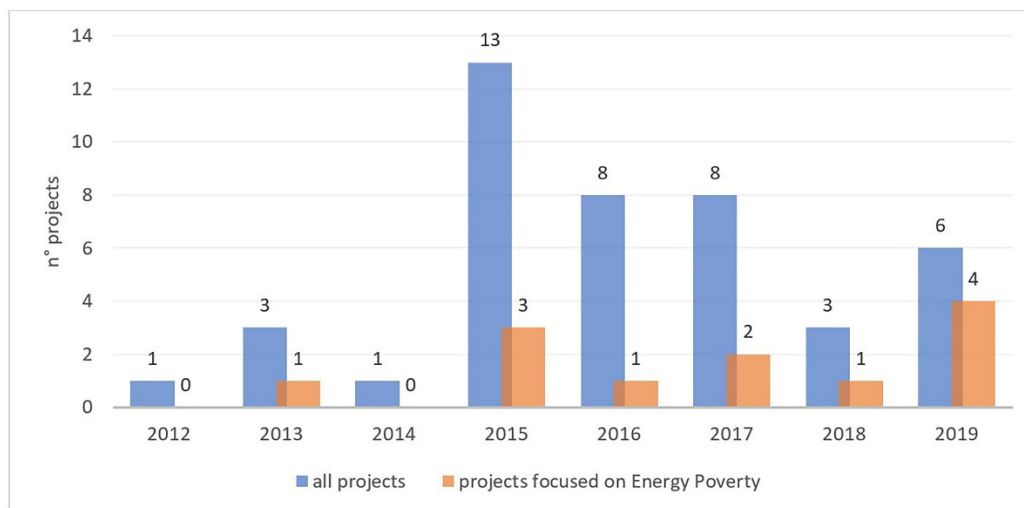


Figure 2. Number of projects per year. Image elaborated by the authors.

3.2. Comparison and Filling Results

After the identification phase, more extensive information on ongoing and completed projects was gathered through dedicated projects’ websites, EU online databases, scientific contributions, research outputs and reports, and dissemination and communication materials.

Each selected project has been reported in a factsheet, containing the information set out below in Table 1.

Table 1. Project factsheet content example.

ACRONYM—Description	
Program(s)	Funding scheme
Topic(s)	Start date
Call for proposal	End date
Coordinator	
Partners	
Involved countries	
Target groups	
Objectives	
Methodology	
Expected results	
Outputs application scale	
Energy poverty perspective and/or related topics addressed in the project	
Energy poverty assumed definition	
Indicators	
Case study (if present)	
Geographic position (country/region/city/district)	
Type (private housing/social housing/nonresidential buildings/systems etc.)	
Purpose/Outputs	
Data Sources	Links

As shown in Figure 3, there is a clear prevalence of projects under H2020-EU.3.1.1 “Reducing energy consumption and carbon footprint by smart and sustainable use” and H2020-EU.3.3.7 “Market uptake of energy innovation—building on Intelligent Energy Europe” programs. When interpreting the graph, it should be considered that some projects are financed by two programs and are therefore counted twice. This is the case of three representative projects that appear both in H2020-EU.3.1.1 and in H2020-EU.3.3.7 (“STEP—Solutions to tackle energy poverty”, “EmpowerMed—Empowering women to take action against energy poverty in the Mediterranean”, and “SocialWatt—Connecting Obligated Parties to Adopt Innovative Schemes towards Energy Poverty”). The three projects are submitted under the call “LC-SC3-EC-2-2018-2019-2020: Mitigating household energy poverty”, that is the most specifically addressed at tackling energy poverty. The proposed actions are required to cover at least one of the following objectives [28]:

- facilitating behavioral change and implementation of low-cost energy efficiency measures tailored for energy poor households;
- supporting the set-up of financial and nonfinancial support schemes for energy efficiency and/or small-scale renewable energy investments for energy poor households;
- developing, testing, and disseminating innovative schemes for energy efficiency/renewable electricity sources (RES) investments established by utilities or other obligated parties under Article 7 (of Energy Efficiency Directive 2012/27/EU) [29]. New projects are expected in the coming years, funded by the Calls for Proposals 2019 and 2020.

As shown in Figure 4, the most represented funding scheme is the Coordination and Support Actions (CSA), dealing with the coordination and networking of research and innovation projects, programs, and policies whose funds for research and innovation per se are covered by other funding sources.

Only one project centered on energy poverty is a Research and Innovation Actions (RIA) project, leading to the development of new knowledge or a new technology. None are Innovation Action (IA) projects, with a closer focus on market activities, aimed at producing or improving products or services. Considering the projects that tackle energy poverty as an implication of the measures designed for other issues, the number of RIA is relevant.

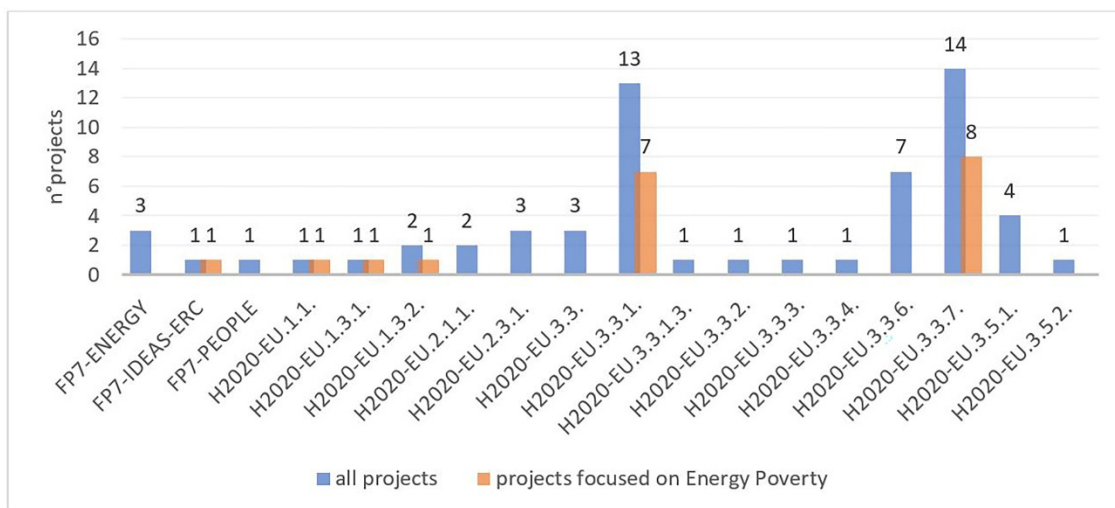


Figure 3. Number of projects per funding program. Image elaborated by the authors.

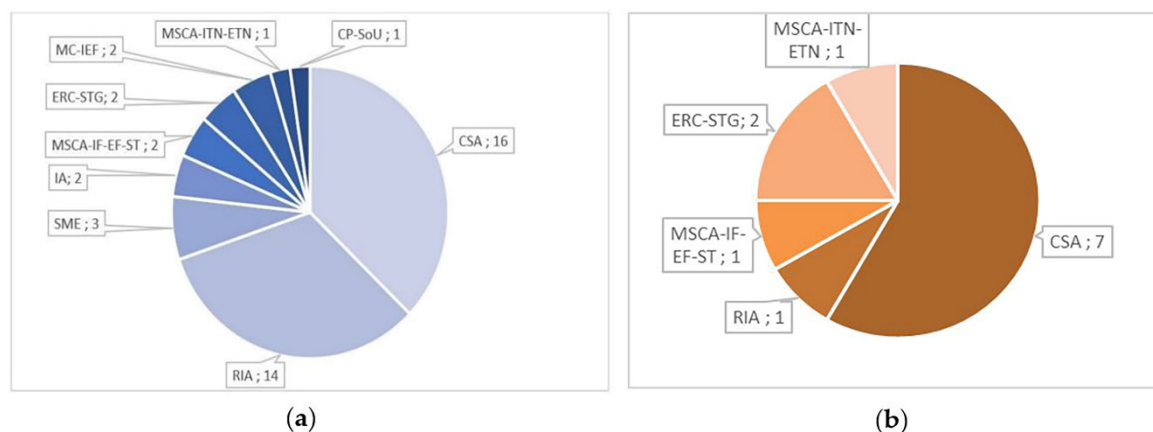


Figure 4. (a) Number of projects per funding scheme; (b) number of projects focused on energy poverty per funding scheme (CSA—coordination and support action; RIA—Research and Innovation Action; SME—Small and Medium-sized Enterprises instrument phase; IA—innovation action; MSCA-IF-EF-ST—Marie Skłodowska Curie Actions—Individual Fellowships—Standard European Fellowships; ERC-SG—European Research Council—Starting Grant; MC-IEF—Intra-European Fellowships (IEF); CP-SoU—Collaborative Project—Scale of Unit; MSCA-ITN-ETN—Innovative Training Networks—European Training Networks. Image elaborated by the authors.

The overall budget of allocated funds is 121,275,563 euro and the prevalent amount range is between 500,000 and 2,000,000 euro.

The geographic distribution of project leaders in EU countries, as well as the distribution of participants stakeholders, is mainly concentrated in United Kingdom, Italy, Germany, and Spain (see Figure 5a). The United Kingdom confirms its centrality in the energy poverty debate and has developed a growing number of national actions and policy frameworks. Although energy poverty affects more consistently the post-socialist Central and Eastern Europe (ECE) countries, only two related projects were developed by countries from this area: EnergyKeeper, coordinated in Lithuania and dealing with the development of an intelligent storage solution to optimize energy demand and supply of isolated communities, and SOLACE ‘System of production and delivery self-assembly, carbon neutral, energy positive, and income generating house, which reduces housing overburden declining inequality gap’, coordinated in Polonia and facing the challenge of rethinking house construction to allow people in need to live in a decent and sustainable way.

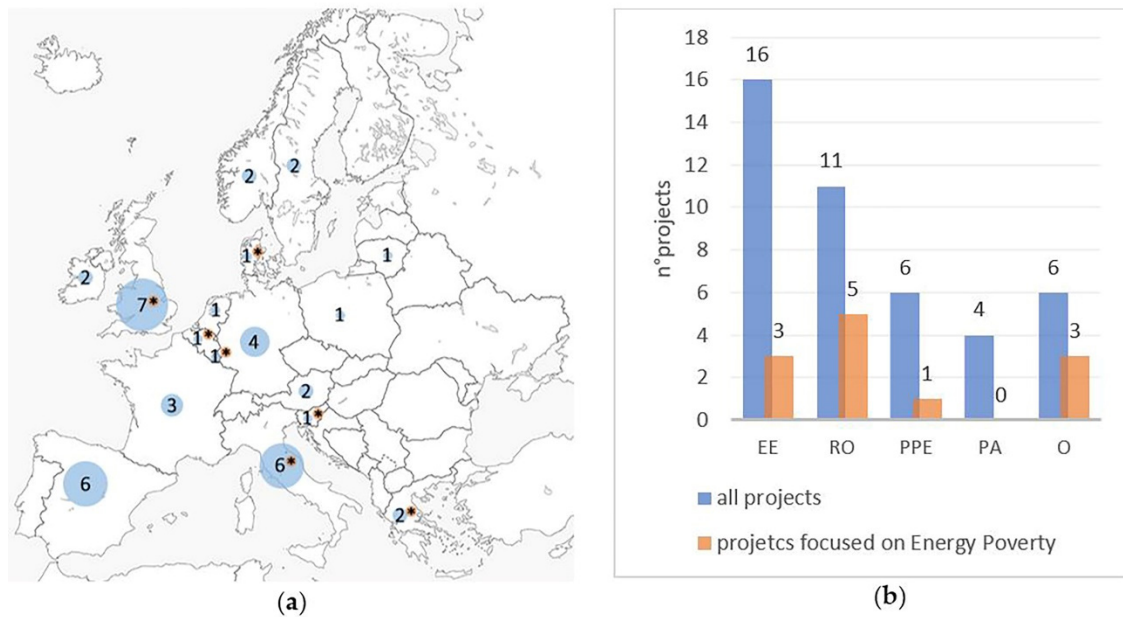


Figure 5. (a) Project leader distribution (* pointed projects specifically focused on energy poverty); (b) number of projects per type of coordinator (EE—education establishments; RO—research organizations; PPE—private for-profit entities; PA—public administrations; and O—others). Image elaborated by the authors.

The coordination of projects is largely entrusted to universities and research organizations (see Figure 5b).

As shown in Figure 6, most of the projects are addressed at consumers, but only a few are specifically tailored to set practical energy efficiency measures helping households at risk or in energy poverty conditions. A significant percentage of projects also involve public administrations and policy makers, while a minor percentage comprises energy utilities whose presence is more frequent as project partners.

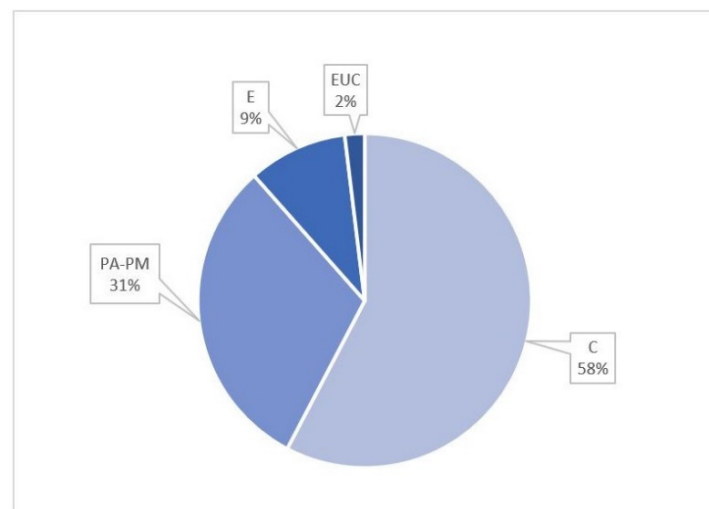


Figure 6. Percentage of projects per addressed target group. (C—consumers; PA-PM—public administrations and policy makers; E—entrepreneurs; and EUC—energy utility companies). Image elaborated by the authors.

The objectives of the surveyed projects are often multiple and combined. In general, the projects show a lack of specific attention to the needs of vulnerable consumers and the wider social aspects of energy poverty (see Figure 7a).

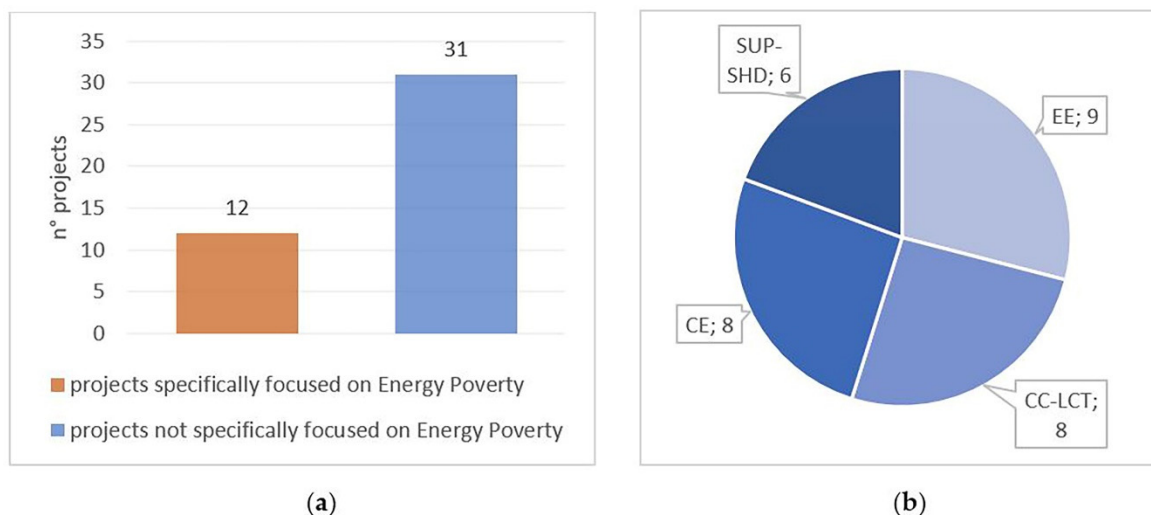


Figure 7. (a) Number of projects specifically focused on energy poverty and projects not specifically focused on it; (b) main issues addressed by projects not specifically focused on energy poverty (CC-CET—climate change and low carbon transition; EE—energy efficiency; CE—citizens engagement; SUP-SHD—sustainable urban planning and social housing districts). Image elaborated by the authors.

The significant number of detected pertinent projects has allowed us to split energy poverty-centered projects from nonenergy poverty centered ones. For the latter category, the main topics that energy poverty has been coupled to or that feature energy poverty as a related impact were identified and grouped as follows:

- Citizens engagement—involvement of vulnerable consumers in order to improve their awareness, to guide them in the adoption of behavioral changes aimed at reducing energy consumption and to support them in the digitization process;
- Climate change and low-carbon transition—policies and actions to tackle climate change and its impacts without negative repercussions on vulnerable citizens; initiatives to fulfil the key objectives of the European Strategic Energy Technology Plan (SET Plan);
- Energy efficiency—developing and monitoring technological solutions for Near Zero Energy Buildings (NZEB) and building retrofiting. Solutions involve the development of plant systems, building components, and technological systems to reduce consumption and generate energy savings;
- Sustainable urban planning and social housing districts—strategies towards urban planning renovation, regeneration of public spaces, social housing and vulnerable districts, and the pursuit of nearly zero energy cities.

In Figure 7b, the 31 non-focused projects are divided according to the groups of related abovementioned topics: those dealing with citizen engagement, climate change, and low-carbon transition are approximately in equivalent number.

As energy poverty is mainly the product of the energy efficiency of the house, combined with the cost of heating fuel and the household income, Member States have promoted a range of policy measures to move the majority of the population out of fuel poverty involving these three factors and generating the most relevant instruments and practices assessed in the literature [10]. A first category of measures includes financial support and social tariffs, targeted for groups of vulnerable consumers, such as low-income citizens, single parents, over-consumer households, large families, the unemployed,

or the retired. Reducing energy poverty through financial support does not tackle CO₂ emissions as it allows people living in poor quality houses to use more energy to reach a comfortable thermal level, thereby increasing carbon emissions. A second category includes, on the one hand, household energy efficiency solutions to improve envelopes, heating/cooling systems, and household appliances, and on the other, the possibility of obtaining subsidies, grants, or tax reductions for energy efficiency improvements and investments. Making homes more energy efficient is a long-term sustainable solution, which allows people to use less energy to heat/cool their homes adequately with a positive impact on carbon emissions. For this reason, energy efficiency is recognized as an important driver in tackling energy poverty [30].

The H2020 projects dealing with climate change and low-carbon transition often intersect those dealing with sustainable urban planning and social housing districts. The common ground is the Strategic Energy Technology Plan (SET-Plan) that in key-action three focuses on new technologies and services for consumers and is composed by SET-Plan 3.1 “smart solutions for energy consumers” and SET-Plan 3.2 “smart cities and communities”. Action 3.1 aims at the creation of a digitalized eco-system where consumers, companies, or stakeholders can offer or use energy services for houses and commercial buildings in cities through different sources of data, using real-time monitoring and control [31]; Action 3.2 aspires to create the conditions for planning, deployment, and replication of 100 Positive Energy District (PED) by 2025 for sustainable urbanization [32].

4. Open Issues and Future Trends

The main open issue and object of debate is still the definition of energy poverty itself, its conceptual identification, and the detection of appropriate statistical measures (Hills, 2012) [24]. Academics have different opinions about the need of a common definition: Thomson et al. [33] and Dobbins et al. [34], argue that a common definition and approach could facilitate the recognition of the problem at EU level, paving the way for more detailed national definitions and encouraging synergies between Member States. Others [35], among them Grevisse et al. [36], argue that, given the significant context differences, a common EU definition is undesirable, and the choice of energy poverty definitions and policies should rest with Member States [11]. In particular, the identification of an absolute threshold for energy poverty at the European level has turned out to be very challenging, making it preferable to develop more regionally specific and targeted settlement-level data [8] (p.34). For this reason, the EU Directive 2019/944 and the EU Regulation 2018/1999 state that energy poverty must be evaluated taking into account the necessary domestic energy services needed to guarantee basic standards of living in the relevant national context [22].

In the examined projects, the limited availability of relevant and comparable data, often collected for other purposes, makes it difficult to get quantitative and measurable results. Moreover, projects often use different methodologies to estimate or measure results; therefore, shared and standardized monitoring, evaluation, and reporting is needed in order to identify and provide evidence of successful solutions and to boost their scaling up and replication [23] (p.53). The STEP-IN project suggests the adoption of the EU Energy Poverty Observatory (EPOV) indicators, divided into four primary indicators (arrears on utility bills, low absolute energy expenditure, high share of energy expenditure in income, and inability to keep home adequately warm) and secondary indicators, related to energy poverty but not directly addressing energy poverty itself, e.g., energy prices and dwellings-related data. According to the ASSIST’Support Network for Household Energy Saving Smart Ventilation Control’ project, the more widespread indicator is the Low Income High Costs indicator (LIHC): low income high costs, defined by Hills in 2012 [24]. For Belgium, Poland, Spain, Finland, and the UK this indicator was already available. In Italy, there are data and statistics about income and energy expenses; however, currently they cannot be correlated, thus, depending on the different goals, different indicators are in use. Among them, an adapted LIHC indicator has been proposed [37].

Another open issue is the development and implementation of a consumer engagement strategy: in many selected projects, the engagement of energy-poor/vulnerable households is considered of outmost

importance to the achievement of the project's objectives. The social, cultural, and behavioral perspective of energy poverty is becoming more and more central. Citizen empowerment and engagement is at the core of the 'Clean Energy for all Europeans (CEP)' whose purpose is to ensure a clean and fair energy transition at all levels of the economy. The CEP attributes a crucial role to citizens and community activities, introducing the energy community into the regulatory framework. According to the CEP, the democratization of energy will alleviate energy poverty and protect vulnerable citizens [14] (p.12). Strategies aimed at supporting consumer awareness, participation, and trust and building confidence and sense of community emerge as a mainstream and cross-cutting issue, to be integrated into projects, actions, and policy. An ongoing representative pilot project is the GECO—Green Energy Community, financed by Climate-KIC, coordinated by the Modena Energy and Sustainable Development Agency (AESS), ENEA, and the University of Bologna [38]. GECO started in July 2019 and aims to promote the production and self-consumption of renewable energy in two districts of Bologna through the creation of a local energy community, involving local inhabitants, commercial activities, and companies [39].

As the H2020 program will expire in the present year, the new European Union Framework Program for Research and Innovation 2021–2027 is being completed (Horizon Europe). The mapping of relevant H2020 calls and related projects has been a step of the development construction process of the strategic plan for Horizon Europe, helping addressing key challenges. Among them, behavioral factors and participative practices are confirmed crucial issues, in particular those using co-designing solutions, building on vulnerable consumers' real needs and expectations.

In the currently available Horizon Europe documents, in particular those discussed within the ECTP innovative built environment platform—EeB committee, energy poverty is not explicitly mentioned, but some of the main open issues are included in the draft clusters. According to the 31 October 2019 draft of the orientation document (orientations towards the first strategic plan for Horizon Europe revised following the co-design process) [40], cluster 1, 'health', is devoted to identifying the environmental and social health determinants in order to improve the understanding of health drivers and risk factors generated by the social, economic, and physical environment. It aims also to promote healthy lifestyles and consumption behavior, with special attention to vulnerable and disadvantaged people. Cluster 2, 'culture, creativity, and inclusive society', will support actions to tackle social, economic, and political inequalities; cluster 4, "digital, industry, and space", will contribute to developing a low-carbon, circular, and clean industry and fostering societal engagement in the use of technologies; and cluster 5, 'climate, energy, and mobility', will contribute to the technological, economic, and societal transformations required to achieve climate neutrality, ensuring at the same time a socially fair transition.

5. Conclusions

In spite of the European legislation efforts to explicitly recognize the energy poverty issue and provide a common framework for the protection and improvement of the conditions of vulnerable consumers, these efforts have not yet been converted into agreed measures, lacking common EU-wide understanding of the phenomenon, while policies to be adopted to pursue this objective are far from plain and unambiguous.

The heterogeneity of interventions reflects the terminological uncertainty, motivated also by the lack of common parameters to define 'energy poverty' at EU level and the variety of causes of energy poverty. These causes can be very different, depending on the various contexts of the considered countries. Consequently, it is quite difficult to define common indicators and to find relevant quantitative data to characterize on a same basis the different national situations. Moreover, as it has already been pointed out, many projects pursue multiple objectives that complement each other but often compete for priorities and budget.

The JRC report stated that "time-trend data for all project categories suggest that the growing attention attracted by energy poverty at policy level in recent years has not yet been reflected in the research and innovation initiatives carried out to date with EU financial support" [23] (p.12), proving

how more projects with a clearer focus on energy poverty and vulnerable consumers would improve the understanding of this phenomenon and help identify effective solutions to address it. The recognition of EU Research and Innovation projects reported in the present paper, only including H2020 and FP7 funded projects, shows that 2019 has been a turning point year: after the JRC publication, three projects have been funded under the H2020 topic LC-SC3-EC-2-2018-2019-2020—mitigating household energy poverty” and new projects are further expected in the present year as the call for proposal is still open.

FP7 and H2020 programs leave a considerable number of open issues about energy poverty and protection of vulnerable consumers. The geographic prevalence of project case studies in the north west countries and the insufficient theoretical and applicative studies in the north east and Mediterranean countries, where energy poverty affects a considerable percentage of the population, still remain a weakness. Only a few funded projects address the issue of energy poverty from a geographical point of view, focusing on the most vulnerable areas. One is EVALUATE ‘Energy Vulnerability and Urban Transitions in Europe’, funded in 2013 under FP7 program, operating in the post-socialist countries of Central and Eastern Europe. A more recent one is EmpowerMed ‘Empowering women to tackle action against energy poverty in the Mediterranean Sea region’, funded in 2019 and focusing on the engagement and involvement of women as main operators in the management of households. Both the behavioral and the gender perspective are worthy of further investigation and Horizon Europe is expected to head in this direction.

Another interesting and promising result emerging from the project review is the cross cutting and multidisciplinary approach: many projects address energy poverty in an integrated way by merging the spatial dimension with social and technological experimentations. However, a significant number of projects address only technological or energy issues through the development of specific building components, thus confining their contribution to the building scale.

In conclusion, the review of FP7 and H2020 funded projects demonstrates that the EU Research and Innovation initiatives are developing a better understanding of the types and needs of energy-poor households and are demonstrating innovative strategies to address energy poverty. Their piloting innovative solutions on vulnerable consumers, despite the aforementioned limits and shortcomings, help to face and anticipate problems, in order to catch the opportunities and build/create inclusive energy communities.

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Appendix A

Table A1. List of FP7 and H2020 selected projects.

n°	Acronym	Period	Description
01	STEP-UP	2012–2015	Strategies Towards Energy Performance and Urban Planning
02	EVALUATE *	2013–2018	Energy Vulnerability and Urban Transitions in Europe
03	R2CITIES	2013–2017	Renovation of Residential urban spaces: towards nearly zero energy cities
04	PACE	2013–2015	Property Assessed Clean Energy
05	INSIGHT_E	2014–2017	Interdisciplinary Strategic Intelligence wareHouse and Think-tank for Energy
06	REMOURBAN	2015–2019	REgeneration MOdel for accelerating the smart URBAN transformation
07	USES *	2015–2018	Understanding Social-Ecological Systems: Coupling population and satellite remotely sensed environmental data to improve the evidence base for sustainable development
08	SMARTESS	2015–2021	Social innovation Modelling Approaches to Realizing Transition to Energy Efficiency and Sustainability Innovate
09	GREEN-WIN	2015–2018	Green growth and win-win strategies for sustainable climate action
10	QBOT	2015–2017	Fast and economic insulation of buildings using robotic systems
11	CD-LINKS	2015–2019	Linking Climate and Development Policies—Leveraging International Networks and Knowledge Sharing
12	ENTRUST	2015–2018	Energy System Transition Through Stakeholder Activation, Education, and Skills Development
13	SMART-UP	2015–2018	Vulnerable consumer empowerment in a smart meter world
14	EnerGAware	2015–2018	Energy Game for Awareness of energy efficiency in social housing communities
15	COMBI	2015–2018	Calculating and Operationalizing the Multiple Benefits of Energy Efficiency Improvements in Europe
16	Decent Living Energy *	2015–2019	Energy and emissions thresholds for providing decent living standards to all
17	LEMON *	2015–2020	LEMON Less Energy More OpportuNities
18	TRIBE	2015–2018	TRaIningBehaviors towards Energy efficiency: Play it!
19	REEM	2016–2019	Role of technologies in an energy efficient economy—model-based analysis of policy measures and transformation pathways to a sustainable energy system
20	Think Nature	2016–2019	Renovation of Residential urban spaces: Towards nearly zero energy CITIES
21	ABRACADABRA	2016–2019	Assistant Buildings' addition to Retrofit, Adopt, Cure, and Develop the Actual Buildings up to zeRo energy, Activating a market for deep renovation
22	ECHOES	2016–2019	Energy CHOices supporting the Energy union and the Set-plan
23	EnerSHIFT *	2016–2020	Energy Social Housing Innovative Financing Tender
24	ENERGISE	2016–2019	European Network for Research, Good Practice, and Innovation for Sustainable Energy
25	ENABLE.EU	2016–2019	Enabling the Energy Union through understanding the drivers of individual and collective energy choices in Europe
26	INNOPATHS	2016–2020	Innovation pathways, strategies, and policies for the Low-Carbon Transition in Europe
27	SAVES2 *	2017–2020	Students Achieving Valuable Energy Savings 2

Table A1. Cont.

n°	Acronym	Period	Description
28	EnergyKeeper	2017–2019	Keep the Energy at the right place!
29	ASSIST *	2017–2020	ASSIST - Support Network for Household Energy Saving
30	AirEX	2017–2018	Smart Ventilation Control
31	SOLACE	2017–2017	System of production and delivery self-assembly, carbon neutral, energy positive, and income generating house, which reduces housing overburden declining inequality gap
32	AZEB	2017–2020	Affordable zero energy buildings
33	InBETWEEN	2017–2020	ICT enabled BEhavioral change ToWards Energy EfficieNt lifestyles
34	PV-Prosumers4Grid	2017–2020	Development of innovative self-consumption and aggregation concepts for PV Prosumers to improve grid load and increase market value of PV
35	TRANSFAIR	2018–2020	Unfair transitions? A critical examination low-carbon energy pathways in the EU from a domestic energy vulnerability perspective
36	STEP-IN *	2018–2020	Using Living Labs to roll out Sustainable Strategies for Energy Poor Individuals
37	SCORE	2018–2021	Supporting Consumer Co-Ownership in Renewable Energies
38	STEP *	2019–2021	Solution to Tackle Energy Poverty
39	EmpowerMed *	2019–2023	Empowering women to take action against energy poverty in the Mediterranean
40	SocialWatt *	2019–2022	Connecting Obligated Parties to Adopt Innovative Schemes towards Energy Poverty
41	ODYSSSEE-MURE	2019–2021	Monitoring EU energy efficiency first principle and policy implementation
42	Smart BEEjs *	2019–2023	Human-Centric Energy Districts: Smart Value Generation by Building Efficiency and Energy Justice for Sustainable Living
43	HIROSS4all	2019–2022	Home integrated renovation one-stop-shop for vulnerable districts

* Projects specifically focused on energy poverty.

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